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Test on Loss Between Wires at High Tension.

LESS than a year ago some tests were made in the laboratories of one of the largest electrical manufacturing concerns in the East to determine the energy loss which takes place on a transmission line of high pressure, due to direct leakage through air from one line wire to the other. Various sizes of wire and cable were used. The distance between wires was varied from 8 inches to 36 inches. The electromotive force ranged from 20 to 60 kilovolts.

A comparative test was made upon a No. 14 B. & S. bare and No. 14 B. & S. rubber-covered copper wire in order to determine whether or not any difference in loss existed. This showed that the loss in the case of the rubber-covered wire is less than that between bare wire of same size and distance between wires.

Frequencies of 50, 60 and 133 periods per second were employed. The loss was determined as follows: A Weston wattmeter was inserted in the low-voltage side of the bank of step-up transformers and the leakage of the transformers at the voltage used was measured. Next the line was connected in and another reading taken. Then, to determine if any loss was due to the leads coming from the transformers, an attempt was made to measure this, but it was so small as not to permit any accurate reading. It was therefore neglected.

A hissing sound was noticed when the line was connected in, but this noise was not affected by changing the distance between wires, though it seemed to be somewhat less with large wires than with smaller ones. When examined in the dark, the smaller wires showed a glow around them, with spots or beads at irregular intervals, indicating possibly that these points were some nodal point of the electrical oscillations or else due to a greater surface density at those points. When large cables were used, this glow disappeared entirely, but was still seen at the insulators and tie wires. Its color was a pale violet. The five raising transformers used were connected with primaries in multiple and secondaries in series, a Weston wattmeter being placed in the main supplying the 100-volt primaries.

A mili-ammeter was placed in series with one high-tension wire, but no reading was obtained, showing that the current flowing in the line was inappreciable.

A comparative test was made between iron and copper wires of same diameter and same length, which showed no difference in the losses.

Table No. 3 assumes poles of pole line to be set 120 feet apart (44 per mile), a number of tie wires being placed on the line equivalent to the number per half-mile and the loss measured. First the ends of these tire wires pointed toward, and then away from one another, thus:

First—Distance between line wires, 12 inches; between points of tie wires, 8 inches.

Second—Distance between line wires, 12 inches; between points of tie wires, 16 inches.

The results of tests are given in the following tables, which are self-explanatory:

TABLE NO. 1.

No. B. & S.	Kind of Wire.	Diam. of Wire.	Circular Mils.	Length of Line.	Dist. bet. Wires.	50 P. P. S. E. M. F.	50 P. P. S. Loss in wts.	60 P. P. S. E. M. F.	60 P. P. S. Loss in wts.	133 P. P. S. E. M. F.	133 P. P. S. Loss in wts.
	Alum. Cable	.9375 in.	509800	13½ ft.	8 in.	50000	....	49500	13	50000	....
					10 "	5000	....	.....	...	50000	20
					12 "	50000	8	49500	8	50000	17
					14 "	5.000	....	.....	....	50000	13
					16 "	.....	5	49500	6	50000	12
					18 "	.....	....	.....	....	500 0	....
					24 "	.....	3	49500	4	50000	10
					30 "	.....	....	.....	....	5.000	....
	Alum. Cable	.637 in.	306398	12¾ ft.	8 in.	.....	....	49500	20	50000	....
					12 "	.....	....	493 0	17	50000	....
					16 "	.....	....	49500	14	50000	....
					20 "	.....	....	4950	11	50000	....
					24 "	.....	....	49500	10	50000	....
					30 "	....	....	4950	7	50000	....
No. 26	Copper	.016 in.	256	11½ ft.	8 in.	50000	75	50200	8	50000	115
					12 "	50000	45	50200	45	50000	80
					14 "	50000	37	50200	40	50000	7
					16 "	50000	20	50200	35	50 00	65
					18 "	50000	27	502 0	30	500 0	60
" 26	Copper, Double Length	.....	.....	23 ft.	8 "	.....	...	50000	175	5 0	....
					8 "	.....	...	41700	95	50000	....
					8 "	.....	....	30600	57	50000	....
					8 "	.....	....	20000	40	50000	....

TABLE NO. 2.

All the following tests made at 60 p. p. s.

No. B. & S.	Kind of Wire.	Diam. of Wire.	Circular Mils.	Length of Line.	Dist. bet. Wires.	E. M. F.	Loss in Watts.
No. 14	Copper, Bare	.064 in.	4096	11½ ft.	8 in.	49500	45
					10 "	49500	40
					12 "	49500	32
					14 "	49500	28
					16 "	49500	26
					18 "	49500	25
No 14	Copper, with Rubber Insul.	.....	.....	.....	8 in.	495 0	35
					10 "	49500	15
					12 "	49500	13
					14 "	46500	10
					16 "	495 0	8
					18 "	49 00	5
No. 16	Copper	.051 in.	2601	11½ ft.	8 in.	49500	60
					10 "	49500	50
					12 "	49500	42
					14 "	49500	38
					16 "	49500	33
					18 "	49500	28

TABLE NO. 2—Continued.

No. B. & S.	Kind of Wire.	Diam. of Wire.	Circular Mils.	Length of Line.	Dist. bet. Wires.	E. M. F.	Loss in Watts.
No. 22	Copper	.025 in.	625	11½ ft.	8 in.	49500	73
					10 "	49500	55
					12 "	49500	45
					14 "	49500	35
					16 "	49500	32
					18 "	49500	30
	Iron	.025 in.	625	11½ ft.	8 "	49500	73
					10 "	49500	57
					12 "	49500	40
					14 "	49500	34
					16 "	49500	31
					18 "	49500	29
	Alum. Cable	.9375 in.	509800	13½ ft.	10 "	60000	20
					12 "	60000	14
					24 "	60000	9

TABLE NO. 3.

Test with 22 tie wires on each Aluminum Cable.

	Diam. of Wire.	Circular Mils.	Length of Line.	Dist. bet. Wires.	E. M. F.	Loss in Watts.
Tie wires pointing toward each other	.9375 in.	509800	13½ ft.	12 in.	49500	33
Tie wires pointing away from each other	.9375 in.	509800	13½ ft.	12 in.	49560	14
Same cable without tie wires or insulators, and supported by silk cord.....	.9375 in.	509800	13½ ft.	12 in.	49500	8

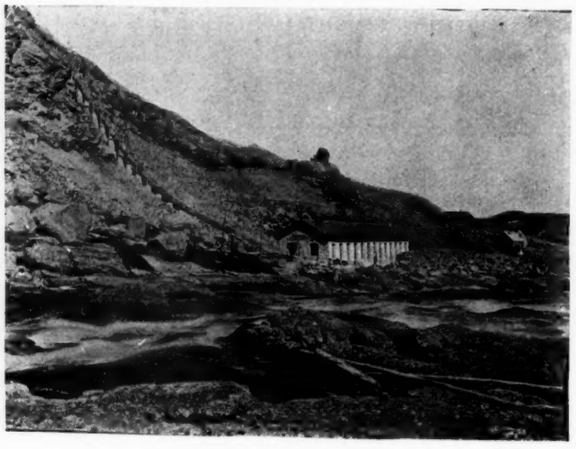
Tie wires of No. 6 B. & S copper wire.

Transmission

ELECTRICAL TRANSMISSION IN NEW FOUNDLAND.

BY R. F. MARKILL,
(Engineer in charge of sub-station.)

NEW FOUNDLAND abounds with small and large freshwater ponds, many of which are so situated that, with very little expense, they can be turned into valuable sources of power. About eight miles from St. Johns, high in the hills which form the rugged coast line of the island, are a number of these ponds, emptying into the sea at a small fishing village called Petty Harbor, and here it is that R. G. Reid, the great land proprietor and railway magnate of the island, has built the power-house for the electric transmission plant that, on May 1, 1900, began to supply energy for the operation of the first electric railway system in St. Johns—the system of the "St. Johns Electric Railway."



POWER HOUSE, PETTY HARBOR, SHOWING IRON PIPE LINE FROM WOODEN FLUME.

At present only two lakes have been dammed, one having an area of 25,000,000 square feet and the other 1,000,000 square feet, making a total of 26,000,000 square feet. Besides these two reservoirs now in use, there are two others within close proximity having areas of 9,000,000 and 31,000,000 square feet, respectively. A dam and gate are at the mouth of the larger lake to

SUB-STATION, ST. JOHNS.

regulate the flow of water, as is required, so that there may be no waste.

From the mouth of the smaller lake a wooden flume 3468 feet in length, carried along the side of the hill, conducts the water to a point 187 feet above the power-house. It is constructed of native spruce 8 ft. x 8 ft. framed timbers on 3-ft. centers, planked on the bottom with 2½ inch and sides 2 inch. The flume practically ends in a rock tunnel 368 feet long, cemented at the junction. Not any lining is used inside, the rock being sufficiently water tight. At the other end are located the pen-stock and gate. From here a pipe 318 feet long, 6 feet 6 inches in diameter, brings the water into the power-house below. This pipe is made of steel plates ⅝ of an inch thick, anchored to concrete pillars, twenty-two in number, embedded in solid rock. Two anchor bolts 5 feet long, riveted to the sides of the pipe, run through the basin and are bolted to timbers at the back.

The generating station is 138 feet long by 24 feet wide, constructed of native blue stone, with wooden roof covered with sheet iron, cemented floor, and well lighted by large windows. At present only two generators and one water-wheel are installed, but everything is ready for placing another wheel of the same capacity and also two more electrical units. The wheel is of the turbine type, having a rated capacity of 1868 horsepower when operating under a head of 187 feet. The wheel is regulated by an electrical governor. On the shaft is a nine-ton fly-wheel, made up of sheet steel plates, bolted together and turned in a lathe. Two Westinghouse generators are directly connected to the water-wheel, one on either side. They are rated at 600 kilowatts each, revolving armature, three-phase type, running at 327 revolutions per minute, and delivering 500 volts at 60 periods per second. Two exciters furnish the field current for generators and lights for the station. They are directly connected to a 50-horsepower turbine, one on either side of the wheel, arranged in the same manner as generators. They have a capacity of 15 kilowatts each, four pole, 110 volts, 605 revolutions per minute.

The switch-board is the ordinary Westinghouse type, consisting of four white marble panels, two for the generators and two for the exciters, with the usual number of ammeters, Niagara-type wattmeters, voltmeters and a Mershon compensator for loss on the line. The current is conducted from the switchboard to the primary side of the step-up transformers on twelve 500,000 circular mil lead-covered tables. On each transformer is mounted a Westinghouse 500-ampere quick-break switch for the purpose of opening the primary side if necessary. Three Westinghouse transformers of 400 kilowatts each, oil cooled, raise the voltage to 15,000 volts for transmission. They are connected in delta. From

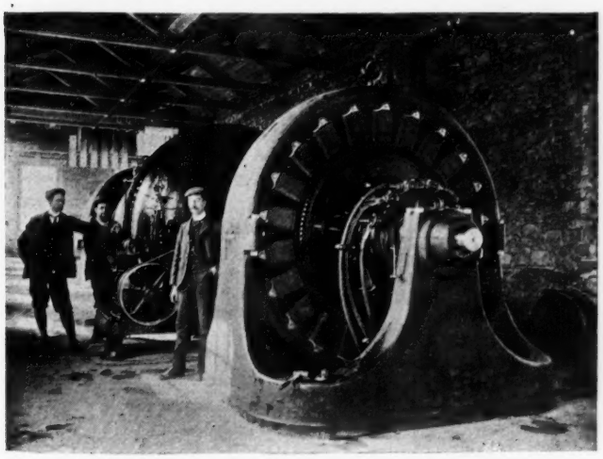
the secondary side the current goes through six high-tension pole switches and circuit breakers to the bus-bars and thence to the pole switches connected to the line circuits. The Wurts lightning arrester is used. These are installed in loft at the end of the building over the high-tension switches.

POLE LINE.

Current is brought into St. Johns over two pole lines, in order to insure against interruption of the servive. The poles are about 125 feet apart; three wires of No. 5 B. & S. medium drawn on each line, Locke three-petticoat glass insulators and locust-wood pins, boiled in parafine wax, are used, as they are believed to give best results where there is so much fog and rain. There is one cross-arm on each pole, with a pin at either end and a pin in the top of the pole, thus forming an equilateral triangle. The wires are not spiraled. A telephone line connects the generating station with the sub-station, wires being transposed every four poles.

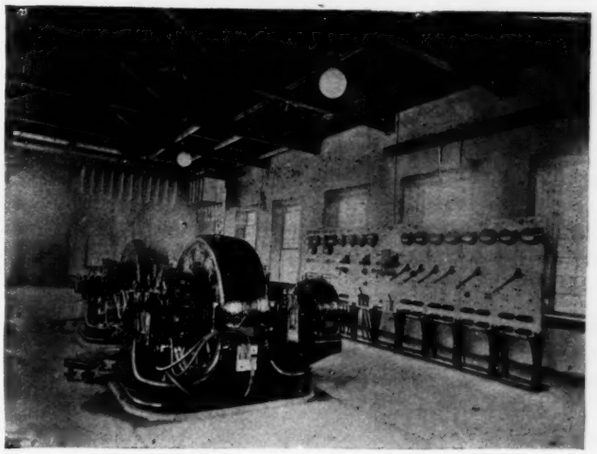
The sub-station is at the west end of the city, just beside the dry-dock. In appearance it very much resembles the power-house, being constructed of the same material and having a concrete floor, etc. The dimensions are 90 feet long by 30 feet wide. Line wires enter the end of the building through high-tension pole switches similar to the one in generating station, thence to the high-tension bus-bars and distributing switches to four 100-kilowatt Westinghouse oil-cooled transformers for two rotary converters. The transformers are connected Scott system, giving a two-phase current at 400 volts. The sub-station also contains four 150-kilowatt transformers, giving two-phase currents at 2040 volts, used for city circuits. The high-tension switches are pole switches with fuses, each having a marble slab with an air gap of 3 inches between slabs and a shield of asbestos 38 inches by 30 inches. Two rotary converters are at present installed, but foundations are ready for two more. These converters are rated at 200 kilowatts each, speed 720 revolutions, and 500 volts for street railway circuits. The switchboard is of white marble, nine panels in all, four of which are used for the rotary converters and one for railway feeders, the remaining four for light and power, two panels for each. All station appliances are of standard Westinghouse types of latest forms. The remaining interesting feature of the sub-station is that the Manhattan series alternating enclosed arc system will be installed immediately for the street lighting. This will necessitate the addition of one more panel to the switchboard.

The rolling stock of the St. Johns Electric Railway consists of six cars, 32 feet long, equipped with Westinghouse "12a" 30 horsepower, series-parallel, 38 controllers. Four of the cars are



INTERIOR OF POWER HOUSE, PETTY HARBOR.

double-enders. Two sweepers are all ready for the winter season. The track is narrow gage, to be in keeping with the New Foundland Railway, which has a gage of 3 feet 6 inches. Five miles of 50-lb. T rails have been laid and cars are running over them every day; also, 5700 feet of 83-lb. girder rails on the principal street, which at present is being paved. The trolley wire is No. 0 and suspended from poles on either side of the street. Rails are



INTERIOR OF SUB-STATION, CITY OF ST. JOHNS, N. F.

bonded in the usual way and cross-bonded every 400 feet, No. 0 bonds used for 50-lb. rails and 00 for 83-lb. A number of very steep grades are encountered, one short grade of 14 per cent. and several of 7 and 8 per cent. Two or three curves of 45-ft. radius are also met with. As can be imagined, the cars, motors and trucks have had a pretty severe test, but notwithstanding that they have stood it admirably. The cars and trucks were made in Montreal, the former by the Lariviere Car Manufacturing Company and the latter by the Montreal Switch Company.

The city has a population of 35,000 people, of which the majority are interested in the fishing industry. Quite a lot of manufacturing is done, and as coal is very expensive there is a good demand for electric power.

G. H. Massy is consulting engineer, W. A. Mackay is superintendent and electrical engineer, and F. H. Wing is electrical engineer in charge of the generating station at Petty Harbor; and to these gentlemen is due the credit of the building and operation of this highly successful installation.

INDUCTION MOTOR WIRING.

To determine the current per wire for a three-phase induction motor, let kw represent the capacity of the motor in kilowatts, E the voltage of the motor, F its power factor, and e its efficiency. Then the current per wire (C) will be given in the formula:

$$C = \frac{577 \times kw}{E \times F \times e}$$

AN INDUCTION MOTOR PHASE CHANGER.

A novel method of phase transforming, suggested by S. P. Thompson,* consists in equipping the stator of a two-phase induction motor with a three-phase rotor furnished with slip rings for the purpose of introducing resistance into the rotor circuit on starting. Electrical energy applied to the stator as two-phase current will then be converted into three-phase current, which may be taken from the slip rings. The reverse condition, of course, is equally true.

"Clearness and thoroughness of illustration are characteristics of THE JOURNAL."—*American Electrician.*

*American edition of Thompson's "Polyphase Electric Currents," page 333.

Generation

COMPENSATED REVOLVING FIELD GENERATORS.

BY H. G. REIST.

IT is well known that when the load on an electric generator, direct or alternating, is increased, the potential will drop unless the field excitation is also increased. This is due to the resistance of the armature, the inductance of the armature, and the reaction of the armature on the field poles, the latter reducing the amount of effective magnetic flux. The potential at a distant point, when the current is used for lights or motors, falls even more on account of the resistance and inductance of the line. To compensate for this, D. C. dynamos have been compounded by passing the main current through series coils on the poles and so adjusted that the potential at the machine increases with increasing load. On alternating and multi-phase machines the same result has been obtained by rectifying the main or an induced current and using it for the same purpose; and, except for a slight increase in complication, the method is just as effective as on D. C. machines so long as the alternating current is in phase with the potential, which unfortunately is rarely the case in ordinary operation, since partly loaded transformers and induction motors produce a lagging current which requires a greater field excitation to produce the normal potential. This has not heretofore been provided for, but is in the case of the machines to be described.

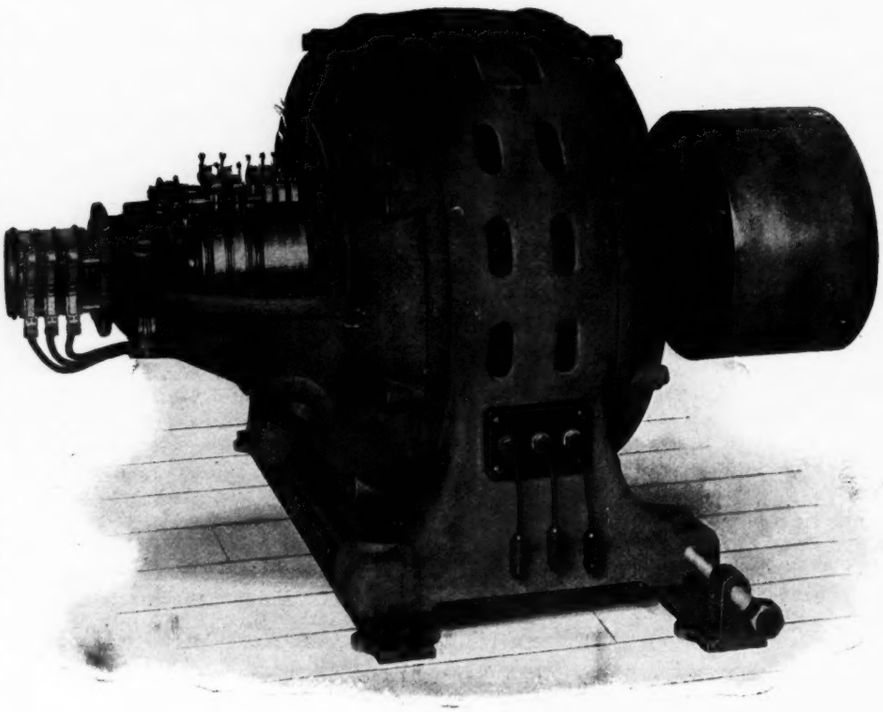


FIGURE 1.—THE G. E. COMPENSATED REVOLVING FIELD GENERATOR.

The line of machines as developed and now being built by the General Electric Company are belted and will fill the wants of installations where the greatest trouble is experienced, *i. e.*, where the size of the motor units is likely to be a large per cent. of the size of generator units.

The design is based on a principle radically different from anything which has heretofore been employed. The new feature is the method of excitation and gives an automatic compounding far superior in results from that which can be obtained by any other known method, and at the same there is nothing but the simplest and most reliable mechanism used.

The distinctive advantage of this method of compounding is that it automatically adjusts the potential for all variations and degrees of inductive and non-inductive load without any mechanical change or adjustment. In any alternator, to maintain a given potential with a given inductive current requires a larger amount of field excitation than is needed with the same potential and load if the current is non-inductive. Thus, in all types of alternators heretofore designed, the compounding required for non-inductive loads has been entirely insufficient for inductive conditions. With the loads that ordinarily have to be provided for on alternating-current circuits there are wide variations in the power factor, especially in cases where a considerable proportion of the load is in motors. Consequently the achievement of an automatic means of field adjustment for all kinds and degrees of load is of the greatest practical value.

METHOD OF COMPOUNDING.

The means by which this result is accomplished are as follows: The shaft of the generator which carries the revolving field also carries the armature of the exciter, which has the same number of poles as the alternator, so that the two operate in synchronous relation. Besides the commutator, which delivers current to the field of the alternator and to the fields of the exciter, the latter contains three collector rings. Over these collector rings it receives current from one or several series transformers inserted into the lines leading from the alternator. This alternating current passing through the exciter armature, reacts magnetically upon the exciter field in proportion to the strength and to the phase relation of the alternating current. In consequence thereof the magnetic field, and hence the voltage of the exciter, is due to the combined effect of this shunt field and the magnetic reaction of the alternating current.

The connections between the armatures of the two machines are so made that the polarities induced in the exciter armature are somewhat ahead of the exciter field magnetization, but still so that it will resist the field magnets. The result is that with increasing main current, the current passing through the exciter armature strengthens the exciter fields and thereby the fields of the generator. If the current lags, as under an inductive load, the magnetization produced by the alternating current in the armature comes more nearly in line with the exciter field magnetization, thus strengthening the field more with a given linecurrent. This is so adjusted as to give necessary rise of exciter voltage as non-inductive load increases, and without other adjustment to give a greater rise of exciter voltage with the addition of inductive load. These are the first machines in which this result has been accomplished, and they are consequently the only perfectly compounded alternators. They accomplish the desired result with wonderful accuracy and without any liability to sparking or troubles of any kind.

ACCESSORIES FOR EXCITATION AND COMPOUNDING.

In addition to the exciter armature and its commutator, the alternator shaft carries two sets of collector rings, one set delivering direct current to the alternator field, and the other set delivering alternating current to the exciter armature, as described. The commutator and all the collector rings are fitted with carbon brushes and all operate at pressure below 75 volts, so that all parts may be freely handled under all conditions.

No alternating current is rectified as in other compound alternators, and no conditions exist which will produce trouble through sparking or improper brush action. In fact, one of these machines requires no more care than that which is generally bestowed upon the exciter of a separately excited alternator.

With each alternator is furnished a transformer of compact design for the purposes described above, and a small rheostat which is connected in series with the exciter field winding. These can be mounted wherever convenient. No other accessories are required with the machine except such switchboard arrangements as the service may demand.

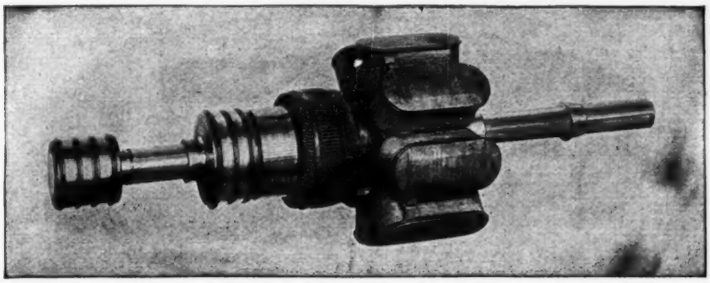


FIGURE 2.– ARMATURE OF COMPENSATED REVOLVING FIELD GENERATOR.

THE DYNAMO PROPER.

The machine is of the revolving field type, with stationary distributed armature winding, the design being such that a vigorous ventilation is maintained through all parts.

The armature coils are insulated in the same manner that coils for high potential machines are insulated. The coil construction is far superior to any other which has been put in practice. The coils are held in place by wooden wedges. This fastening allows the coils to be easily removed and has been found very satisfactory in the vast amount of machinery built in this way. The poles of the revolving field are built up of laminations and are fitted into dovetail slots in the steel hub with taper keys. These keys are easily driven out, so there is no trouble to remove or replace a pole piece. The field coils are made of flat strip copper wound on edge, each coil consisting of a single spiral, paper being used to insulate between successive turns.

MECHANICAL ARRANGEMENT.

The mechanical design of these machines is very compact and convenient. All parts are readily removable. The distribution of weight and pull is such as to give a particularly good action on the bearings. The machines stand on rails so that the belt tension can be adjusted.

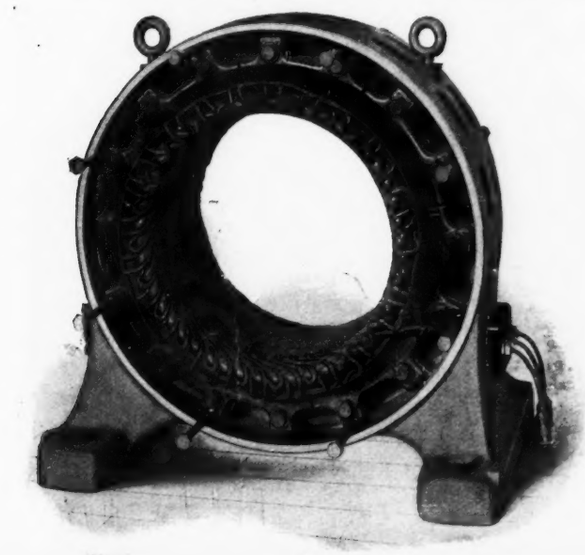


FIGURE 3.—REVOLVING FIELD OF THE G. E. COMPENSATED GENERATOR.

EFFICIENCY.

These dynamos are so proportioned as to afford practically effective use of all the magnetic material. The efficiencies obtained are consequently high, and the weight of the machines per kilowatt output is small. Actual tests show that the efficiencies of these machines are higher than those of any standard belt-driven alternators now made.

PHASES AND VOLTAGES.

The standard designs for these machines are adapted to three-phase or two-phase windings without change save in the coils themselves, the exciter and all accessories being the same for both. There is not standardized any single-phase or monocyclic windings for these machines, the intention for the present being to use three-phase windings for cases for which monocyclic or single-phase machines would ordinarily be required.

These machines will carry their full rated capacity, two or three-phase non-inductive load, continuously with a rise of temperature not to exceed 40 degrees C. in any part, and will carry 25 per cent. overload for two hours without rise of temperature exceeding 25 degrees above the surrounding air. All machines with three-phase windings are guaranteed to carry 80 per cent. of their rated output in single-phase current. Under these conditions the same temperature guarantee can be given as for two and three-phase rating. It is also guaranteed that these machines with three-phase windings will carry their full output in single-phase current for a period of three hours without injurious heating.

APPLICATION TO LIGHTING AND POWER DISTRIBUTION.

The machines can be operated at their three-phase rating when they are used to deliver power for both lighting and motor service, with the lighting distributed for one phase only and the motors connected to all three phase. The machines can be operated in this way where the lighting load is a large proportion of the whole. The reason for this is that the motors tend to draw most of their power from the phases which operate at the highest voltages; consequently the motors tend to correct the unbalanced condition that arises from the operation of lights from a single phase. This is of great practical value, as a single-phase current is for many reasons more convenient than polyphase current for lighting purposes.

While this method of operation is recommended for many installations, the machines are of course practically adapted to any system of polyphase lighting distribution. The machines have been so designed that they can be wound for the following potentials:

Three-phase windings—480, 600, 1150 and 3450 volts.
Two-phase windings—480, 1150, 2300 and 3450 volts.

Machines with three-phase windings and arranged for 2300 volts will be considered as standard and can be more promptly delivered than for any other arrangement of windings and potentials.

CENTRIFUGAL PUMPING AGAINST HIGH HEAD.

An English electrical contemporary illustrates and very briefly refers, in a recent issue,* to a remarkable centrifugal pump and induction motor set that is being used at the Geneva, Switzerland, water works for pumping water to a height of 460 feet.

The pump is driven by direct connection from a two-phase, 1000-horsepower alternating-current induction motor running at 455 revolutions per minute. It takes current at 5000 volts and was built by Brown, Boveri & Co. of Geneva. Presumably this motor is built upon the plans presented as "Plate VII" in the American edition of S. P. Thompson's "Polyphase Electric Currents and Alternating-Current Motors."

* *The Electrical Review*, London, Vol. XLVII, page 494, September 28, 1900.

Distribution

SOME EXPERIMENTS WITH ROTARY CONVERTERS.*

BY A. B. GRIER, B. SC., AND J. C. HYDE, B. SC.

IN the last few years rotary converters have gradually come to the front, and at present are an important factor in some of the most modern and best equipped transforming stations. They form the connecting link between alternating and direct currents in the simplest and most efficient way. During the past session, the following experiments were carried out with rotaries in the electrical engineering laboratories of McGill University.

WAVE FORMS.

The wave forms may be shown as curves taken under different conditions on the two rotaries used.† They show that armature reactions are very small, and that the three-phase form approaches very near a sine wave, practically holding it under all conditions of load. The first four wave forms derived were taken on a double-ended rotary, or one with two separate and exactly similar windings on the one armature body, each winding having its own commutator and collector rings. It was thus possible to run the machine as a rotary converter from one winding and get the induced volts from the other winding. The first curve derived is for an inphase running light current of 13 amperes; the second curve is for a 45-ampere lagging running light current; the third is a 45-ampere leading running light current, and the fourth is a 61-ampere inphase load current. From these curves the effect of armature reactions on the wave form is hardly noticeable. Other curves (Nos. 5, 6 and 7) were taken on the second machine, the greatest distortion of the wave being when the machine was mechanically run as a direct-current generator.

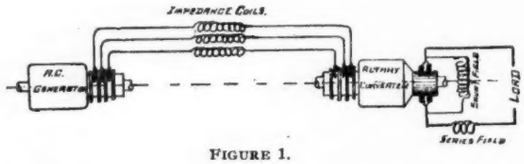


FIGURE 1.

In taking the wave forms, the voltage to be measured was made to charge a condenser, which was then discharged through a Weston voltmeter by means of a suitable disc placed on the end of the shaft.

COMPOUNDING BY IMPEDANCE.

The direct-current voltage of a rotary depends on the impressed alternating current voltage,‡ so that as the direct-current load comes on to keep up the direct-current volts, some means must be used to raise the impressed alternating-current volts. There are two general ways of accomplishing this, viz.: by using induction regulators, or by having impedance coils in the lines which, accompanied with a change in field strength of the rotary, will raise or lower the voltage as required. In some cases where a wide variation is required, both ways are used. The action of the reactance coils may be made entirely self-regulating by having compound turns on the rotary. At no load a good lagging current should be used, gradually working up to an inphase current at about three-quarter load, and a leading current beyond this. Diagram No. 1 shows an alternating-current generator belt-driven feeding a rotary converter with compound turns. This machine when run as a direct-current generator was slightly over-compounded. The machines were used as three-phasers. The direct-current regulation of the rotary converter at different loads was first taken without reactance coils in the lines, the impressed alternating-current electromotive force being kept constant throughout. After this three similar reactance coils were placed, one in each line (machines delta connected), and the regulation again taken. In this case a lag of 68° was started with, ending up with a lag of 12°. The terminal voltage of the generator was kept

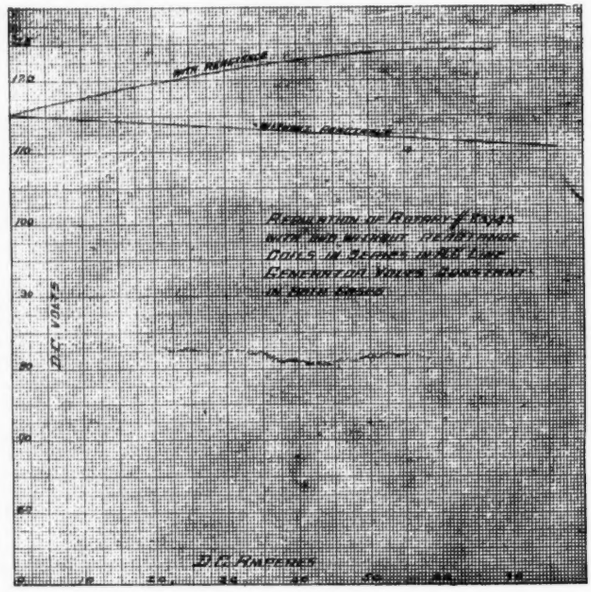


FIGURE 2.

constant at 85 throughout; the volts impressed on the rotary at start were 61.5 and rose to 70 at finish. Another way of seeing the effect of the compound turns on the power factor of the line, is to run the rotary no load (reactance coils in the line), separately excite the compound turns, noting the current in them and the circulating alternating current between the machines. This was done and the results were plotted as per curve No. 2 and 3. The direct-current regulations with and without the reactance coils in the line are also shown. (No. 4.) The frequency throughout was kept constant at 30 cycles.

The following example is typical of the last experiment: Given a transmission line in which the receiver volts are to increase uni-

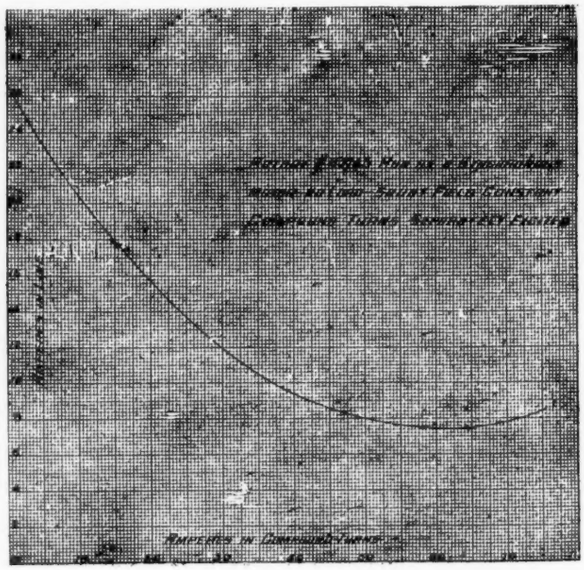


FIGURE 3.

formly with load, 2880 volts at no load and 3160 volts at full load. The energy component of the current at full load being 52 amperes, at three-quarter load the current is to be inphase with

*A paper read before the Canadian Electrical Society, Toronto, Ont., August 28, 29 and 30, 1900.

†Curves so plotted appear in the September, 1900, issue of *The Canadian Electrical News*, Toronto, from which this paper is reproduced.—THE EDITOR.

‡See THE JOURNAL, Vol. VI, page 108, November, 1898.

the electromotive force at the receiver end. The line impedance is $Z = 8 - 30j$. What must be the (constant) generator voltage, the current in the line and the power factor at the receiver end?

Let i = the energy component of the current
Let i_1 = the wattless component of the current
Let I = the total current = $i + j\,i_1$
Let E_0 = generator voltage
Let E = receiver voltage
Then $E_0 = E + IZ = E + (i + ji_1)(r - jx)$; or,
$E_0 = E + ir + i_1x - j\,(ix - i_1r)$

From this formula everything may be calculated, since the generator voltage (terminal) is to remain constant at all loads. The numerical results are as follows, the generator voltage being 3597:

	No Load	¼ Load	½ Load	¾ Load	Full Load
Volts Line.....	2880.	2950.	3020.	3090.	3160.
Energy Current.	0.	13.00	26.00	39 00	52.00
Wattless Current	23.75	17.80	10.01	0.	—12.88
Total Current...	23 75	22.05	27.92	39.00	53.60
Power Factor...	0.	59.0	93 2	100.00	97.0
Lag of Current .	90°	54°	21°	0°	—14°

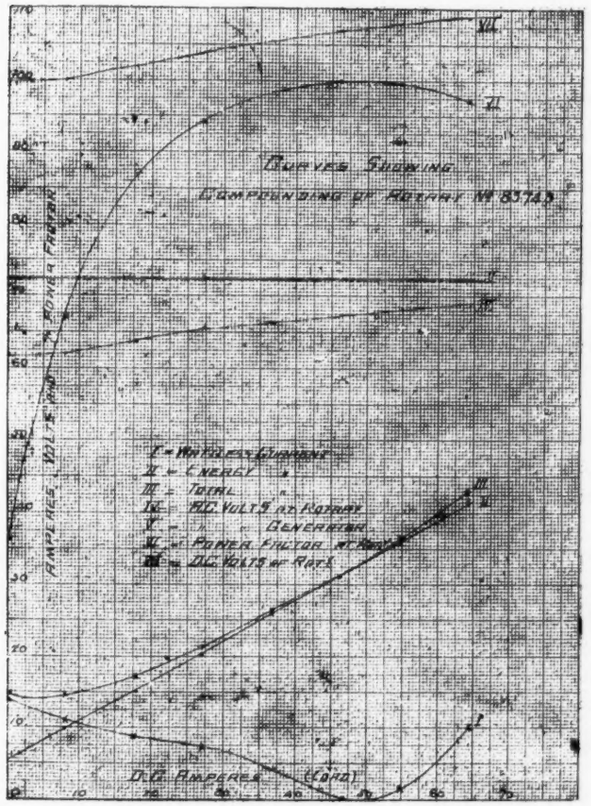


FIGURE 4.

Polyphase rotaries are self-starting from the alternating-current side, and may be thrown direct on the line. One of the rotaries used had solid pole tips and came into synchronism when thrown on the line, but another rotary with laminated pole tips would not, and required to be brought up to speed from the direct-current side and thrown on the line by the aid of phase lamps. It was further found that the first rotary would not come up into complete synchronism if the field switch was closed at the start, but would come up to about half speed and remain there. On opening the field switch, however, it would immediately run up to synchronism.

STARTING ROTARIES.

As there are dangerous voltages induced in the fields when left open in starting in this manner, it is advisable to have the field circuit open in two or more places, as otherwise it would put too great a strain on the field insulation. The machines, when started up in this manner, operate as hysteresis motors; hence the reason of leaving the field switch open. The direct-current polarity also depends on which pole the rotary synchronizes under, and therefore all direct-current meters should be out of circuit until the

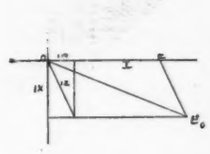


FIGURE 5.

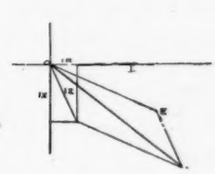


FIGURE 6.

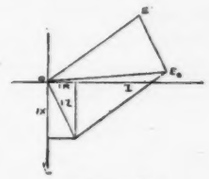


FIGURE 7.

direct-current polarity is tested. Impedance coils may be used for starting in this manner so as not to affect the line voltage too much. Some means of cutting the fuses out of circuit at the start should also be provided.

Since single-phase rotaries are not self-starting, and the alternating and direct currents do not neutralize one another, it is more advisable in this case to use synchronous motors and direct-current generators. It is now the general practice to magnetically connect rotaries on their alternating-current sides when they are required to run in parallel from the same line. This allows of their being connected in series on their secondary sides* without causing the short circuit which would otherwise occur. It also does away with the circulating current occurring when they are connected in parallel on the primary and secondary sides, rendering the direct-current readings valueless.

ROTARIES IN RAILWAY WORK.

In street railways it is very often necessary to cover very large districts. This means very large feeders to keep the drop of potentials within limits. This requires a large outlay for copper and installing, neither is it very efficient. The easiest way to overcome this is to have one main generating station and several sub-stations. In this station would be placed alternating-current generators, and the power should be transmitted to the sub-stations, where there would be placed synchronous motors driving continuous-current generators or rotary converters. As rotaries allow of a simpler means of converting alternating current into continuous current, also being more efficient and allowing of better potential control, they are now nearly always installed for railway work. On account of direct-current potential being directly proportioned to the alternating-current potential, it is necessary to have some means of controlling this in a long transmission line which has considerable resistance and self-

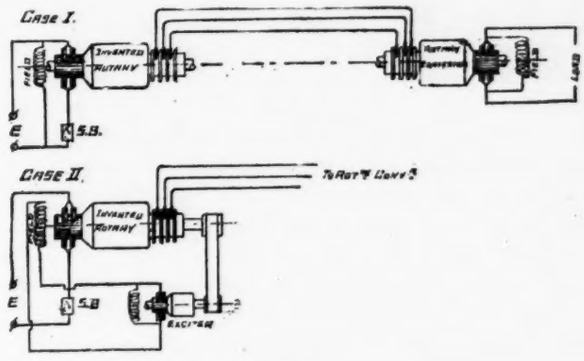


FIGURE 8.

induction. As railway load fluctuates a great deal, it would be difficult to keep the potential constant at the terminals of the converter, especially as the current in the line may remain the

(Continued on page 88.)

*[The secondary or direct-current sides of rotaries may be connected in series only in cases where the primary or alternating-current sides take current from separate transformers.—THE EDITOR.]

THE JOURNAL OF
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EDITORIAL.

OF A GENERAL TREND.

The papers read before the recent annual meeting of the Pacific Coast Gas Association, and which were presented in these columns for September, are by far too important to the interests THE JOURNAL represents to be lightly passed. They reflect not the bigotry of an exclusive industry, but the warmth of co-operative brotherhood in engineering matters of kindred interest. Thus are found within them discussions which trend toward chemical, gas, electrical and steam engineering, with, of course, a preponderance of attention bestowed upon gas subjects, as is natural; but nevertheless he who reads between the lines of gas and electric convention reports will find evidences of broadening ideas that must be gratifying.

Let us see, then, what these avowedly gas-interests papers present that is of value to the electric lighting, power and transmission fraternities.

It is, and perhaps always will be, an open question whether the general public is in greater ignorance concerning electrical matters than it is concerning the principles attending the manufacture of illuminating gas. There is, however, no room for doubting the wisdom of prosecuting a campaign of education to a successful issue, nor will any one discredit the statement that widespread information of a general character concerning any product is the surest forerunner of success in the sale of that product. Thus it was that years were spent before incandescent electric lighting was accepted as being equally as trustworthy as gas; that alternating-current distribution could be provided with adequate safeguards, or that the presence of carbon monoxide in water gas will not decimate the human race. Foolish fears lose their terrors and are dispelled in the light of knowledge, and hence we find at this late day a member of a prominent gas association engaged in a very praiseworthy effort toward popularizing the technical side of the science of making artificial gas. This paper on "The Synthesis of Commercial Gases" is by Mr. Leon P. Lowe, and if he succeeds in realizing his avowed belief "in the policy of liberal education, even to the extent of teaching gas consumers what may seem to them the intricacies of the gas business," he shall have won a name in the industrial world as illustrious as that of his father, who gave to gas engineering its most perfect process—the Lowe system.

There is, after all, nothing so very difficult about the rudiments of gas-making, as Mr. Lowe presents them, simply four elementary substances—carbon, oxygen, hydrogen and nitrogen, variously combined by sundry processes into the different kinds of commercial gases. He says really nothing as to these processes, nor as to the varieties of commercial gases. Perhaps there are points left for consideration in future papers, but it must be said that his present article is an admirable introduction to an acquaintance with the physical characteristics of the elementary substances of which artificial gas is constituted. If Mr. Lowe will continue on in his campaign of education, and will direct his efforts toward processes, and afterward toward products, he will do much to further the cause he has so wisely inaugurated.

One is apt to be inappreciative of the unprecedented possibilities for development that await the Pacific Coast. The trade of a new world containing hundreds of millions of people is rapidly opening up at its gates; its industries show marvelously increasing activity, and its manufactures are at last beginning to increase and prosper under the invigorating influences of cheaper power due to the advent of electrical transmission, to improved steam methods, and to the exploitation of the oil fields of California. The importance of the last-named factor in the development of the manufacturing industries of the Pacific Coast is one that must not be underestimated, and a timely and authoritative discussion of the matter is presented in the paper of Mr. A. S. Cooper, California State Mineralogist, upon the "Characteristics of California Petroleum." The inference from Mr. Cooper's observations is clear that in time the oil fields of California will rival those of Russia in productiveness, and we are already familiar with the fact that the calorific power of certain California fuel oils is higher than that of any other known crude oil.* While it is probable that the present decade will know the benefits that will accrue from the development of these oil fields to a reasonably full measure of their possibilities, it is not believed that the subject is one of immediate vital concern to power producers, for the reason that there is every reason to believe that but little likelihood exists for the reduction of the price of fuel oil from its present figure. Mr. Cooper himself says that "as long as coal remains at $7.50 per ton in California it cannot be expected that oil will fall below its present price, not at least for some time to come." Nevertheless, and even with oil at its present price of $1.40 per barrel of 42 gallons, three and one-third

**Vide* "The Steaming Value of California Fuel Oils," by Geo. H. Larkin THE JOURNAL, Vol. VII, page 24, February, 1899.

barrels of oil are the equivalent of one ton of "good imported coal," Mr. Cooper states, giving the cost of oil to be $4.66 as against $7.50 for its equivalent in coal. Another authority,* however, contends that there is such a great range in the quality of coal used on the Pacific Coast that it is impossible to give any standard of comparison between the use of oil and coal for steaming purposes. In other words, the conditions governing each specific application—such as variety of oil and burner, type of boiler and fittings, quality of coal, etc.—are so diversified that any general statement as to the relative values of the two fuels is not possible in precise terms. It may be stated, however, to quote from the authority last referred to, that, under Pacific Coast conditions, "from two to four barrels of oil are equal to one ton of coal, according to the quality and grade of the coal and the efficiency of the fireman." This statement is followed by a demonstration that 2240 pounds of Welsh anthracite coal is found to be equaled in steaming value by 1540 pounds of oil, from which it appears that the equivalent steaming values of this coal and oil are $8.00 as against $7.14, respectively.

Be these conditions as they may, it seems to be the concensus of engineering opinion that, all things considered, oil is cheaper than coal as a fuel, provided the permanence of supply of the oil is assured, and this conviction is being expressed in the great number of large plants that are being changed over from coal firing to oil burning. Aside from this, however, Mr. Cooper's paper is that of an expert who has succeeded most admirably in presenting succinctly the salient features attending the development of a young and growing industry that is destined to exert an enormous influence upon the manufacturing industries of the most favored section of the most favored country in the world.

The use of gas engines in driving dynamo-electric machinery has been the subject of discussion in these columns so frequently that further reference to it may seem redundant, but the determination of the San Francisco Gas and Electric Company to install a direct-current, gas-engine-driven electric generator in its Edison station marks a departure in the electrical and gas-engineering annals of the country that is not only replete with interest, but promises to be the forerunner of a line of central-station practice that it seems must ultimately be determined upon as being far superior to the steam engine in at least the point of efficiency. And today, practically untried as the gas engine is in American central-station practice, it is impossible to see wherein failure or serious trouble can attend the installation under the conditions in which it is proposed to be operated. The worst that can be said against the gas engine is that its efficiency drops off with more or less rapidity under light loads; that its speed regulation is as yet imperfected, or that repairs are not as easily made as with the steam engine. Answering these criticisms serially: a multi-cylinder gas engine enables one or more cylinders to be cut out under light loads, thereby working such cylinder as may be in use at full load; builders guarantee gas engines to regulate within 2½ per cent., which is very close to the regulation of good steam engines, but despite this, the use of gas-engine-driven dynamos run in parallel with a storage battery and other much larger dynamos, relegates any such question of doubt as to the practicability of the plan into the background as being inconsequential. Finally, some of the reasons why the contract for building the gas engine referred to was awarded to the Union Gas Engine Company of San Francisco are given in Mr. Crockett's paper, and to them may be added the reminder that possible repairs can always be most easily and quickly made to any machinery that is operated in or near to the works at which it was manufactured.

It may be repeated, then, that there seems to be no room for doubting the wisdom of the step that has been taken by the San Francisco Gas and Electric Company. More than this, there is every reason for believing it has marked out for itself a course that will enable it to at least continue to hold its own in its ability to generate electrical energy at the lowest cost possible for a central-station plant.

While on the subject of gas-engine regulation, it is of interest to note the means that have been adopted in a prominent American industrial plant (which will be fully described in a later issue of THE JOURNAL) for eliminating by a simple electrical arrangement all voltage fluctuation due to irregularity in the speed of the gas engine. The installation consists of six 100-horsepower gas engines, each driving a direct-currrent dynamo by direct connection, the electrical energy thus generated being utilized at a point about 1000 feet distant from the generating plant.

Each dynamo delivers its output to the point of consumption over a single line wire, all the six circuits from the six dynamos being brought back over a single large return wire. Whatever fluctuations occur in the voltage at either or any of the six dynamos by reason of irregularity in the speed of the gas engine driving it, is taken up and absorbed by the pulsations of current taking place in the common return, and a constant potential is delivered from the lines.

Mr. Britton's paper on "Introducing Gas Stoves" relates some of the tribulations of the gas man in his efforts to increase his output and load factor by encouraging the use of gas stoves. The situation is analagous to that of the electric-station man who is trying to build up a day motor load, but who does not seem to be able to determine whether he shall sell, loan, or give away with a premium, the electric motor that the prospective consumer must have before another meter can be listed as being in the ranks of industry. Mr. Britton believes that gas used for illumination should be sold through a different meter and at a different rate from that used for fuel purposes. So should electricity be separately metered and charged for when used for lighting and power, but

*Ibid.

despite this universally accepted condition, the exigencies of competition have in some cases thrown the competing companies in the role of burnt-cork artists who, one after the other, slur out the doggerel paraphrase "all juice looks alike to me," for they sell electrical energy, whether used for light or power or whatnot, upon a simple kilowatt-hour basis, without regard to load factor or any other consideration save that of degree of consumption. This is not right, and the time will come when the instigator of this retrogression, whoever he may be, will rue the day he perpetrated it.

Of the remaining papers, that by A. C. Humphreys on "The investigation of Gas Processes" possesses a striking similarity to much that might be written upon experiences which have been had with so-called electrical schemes alleged to be of revolutionizing significance, but which bore in reality such sulphurous and noisome fumes as bespeak an evolution from fakirdom. Gas and electrical engineering might well while away many leisure hours in mutual interest and profit in the interchange of experiences of this character, for each presents means—in the lack of knowledge on the part of the public concerning it—that can be made of use for nefarious ends by unprincipled promoters. Mr. Humphrey's discussion of these unfortunate conditions is emphasized by the relation of many actual occurrences in his own broad experience in gas engineering matters, and his presentation of the subject can only be classed as thorough and most considerate.

EUROPEAN DIRECT-CURRENT TRANSMISSIONS.

The beautiful simplicity of the methods of potential conversion which have become familiar in American transmission practice, is possessed of added charms after reading the leading article in the last issue of THE JOURNAL wherein Mr. Frank C. Perkins, of the Buffalo Electrical Laboratory, describes two high-tension, direct-current transmissions that may be accepted as typical of European practices in this direction. In the Isoverda-Genoa transmission a constant current of 65 amperes, direct current, is used at an electromotive force ranging as high as 13,000 volts, while in the Chaux-de-Fards and Locle direct-current transmission a constant current of 150 amperes at 14,400 volts is in daily use.

In these plants the maximum potential delivered by their generators is 1200 and 1800 volts, respectively; hence in the former transmission ten generators, and in the latter eight generators, are connected in series to give the stipulated line voltage. These dynamos are separately excited, their armatures only are connected in series, and special precautions must be exercised in the insulation of the machines. Moreover, an equipment of equal complication must be installed at the receiving stations, for all distribution from direct-current, high-tension transmissions must be effected through motor-generator sets. A bank of step-down transformers on this system, therefore, consists of a series of direct-current motors cut in on the line, and each driving, by belting or through direct connection, a low-voltage dynamo designed for the particular class of service it is to render.

American engineers with one accord will regard the direct-current, high-tension transmissions of their European brethren as simply incomprehensible when viewed from the standpoint of electro-economics. Why use eight or ten or more dynamos instead of a single one? Why use direct-current commutators instead of collector rings? Why use dangerous high pressures on machines that must be handled instead of harmless low pressures? Why needlessly enhance the cost of station attendance? Why restrict one's self to the use of a system which will admit at most of the utilization of but 25,000 volts or so when the use of more than double that pressure is otherwise feasible? Why do a score or more other things that the use of alternating-current apparatus renders unnecessary?

Superior economy for the direct-current transmission system is claimed, and at first sight its elimination of the use of raising and lowering transformers, with their first cost and their inherent losses, would seem to sustain a contention that American engineers, with their intimate knowledge of the high efficiencies attainable in the alternating field, will be slow to admit.

SOME EXPERIMENTS WITH ROTARY CONVERTERS.

(Continued from page 85.)

same, and still the conditions of load at the other end might vary a great deal. Take the case where current is leading or lagging; a wattmeter in circuit might read the same watts, but in the first case the potential at the generator should be lowered, and in the latter it should be increased. It is therefore necessary to be able to regulate the potential at the converter. This can be done by changing the field excitation of the rotary—that is, changing the phase relation of the current, and therefore increasing or decreasing the potential at the converter, as shown by the previous experiment.

Now as a converter is a synchronous motor on its alternating-current side, we will have the same electromotive forces acting as in a synchronous motor.

First—The impressed electromotive force at terminals.

Second—The counter electromotive force of the converter.

Third—The electromotive force consumed by impedance.

The impressed electromotive force depends on the generator electromotive force. The counter electromotive force is proportional to field excitation, and as its speed is constant, this counter electromotive force is independent of load on the machine. The electromotive force of impedance changes with the load and is proportional to load. The following diagrams (Nos. 5, 6 and 7) will show how generator voltage has to be varied to keep constant voltage at receiving end when phase relation of current is varied.

I—When current is in phase with electromotive force—that is, as non-inductive receiver circuit.

II—When current lags behind electromotive force.

III—When current leads electromotive force.

IR = ohmic drop.
IX = reactive drop.
IZ = impedance drop.
OI = total current.
OE = voltage at machine.
OE_0 = generator voltage.

As these diagrams are drawn to scale, we can see how generator voltage varies with load to keep receiver voltage constant.

For accurate results the analytical method should be employed rather than the preceding method. The analytical method is as follows:

e_0 = generator voltage
e = receiver voltage
i = energy current
i_1 = wattless current
I = total current = $(i + ji_1)$
Z = impedance of line and generator = $r - jx$

Now $e_0 = e + IZ$ (vector sum).
$= e + (r - jx)(i + ji_1)$
$= e + ir + i_1x - J(ix - i_1r)$
$= e + ir + i_1x)^2 + (ix - i_1r)^2$——I.

At non-inductive load $i_1 = o$
Then $e_0^2 = (e + ir) + i^2x^2$——II.
At no load $i = o$ very nearly compared with i_1.
$e_0^2 = (e + i_1x)^2 + i_1^2r^2$——III.

Now, as a converter can be made to take lagging or leading currents, the receiver electromotive force can be varied at will.

Having decided at what point you wish to run non-inductively, it is necessary to calculate the running light current and to adjust the shunt and series field for same. From II and III the running light current may be obtained.

$e_0^2 = (e + ir)^2 + i^2x^2$——II.
$e_0^2 = (e + i_1x)^2 + i_1^2r^2$——III.
Therefore $(e + ir)^2 + i^2x^2 = (e + i_1x)^2 + i^2r^2$.

$$i_1 = -\frac{ex}{Z^2} + \sqrt{\frac{e^2x^2}{Z^4} + i^2 + \frac{zeir}{Z^2}}\text{——IV.}$$

If e = 1 and if it is to be non-inductive at full load, let I = 1.

$$i_1 = -\frac{x}{Z^2} + \sqrt{\frac{x^2}{Z^2} + 1 + \frac{2r}{Z^2}}\text{——V.}$$

If non-inductive at ¾ load

$$1_1 = -\frac{x}{Z^2} + \sqrt{\frac{x^2}{Z^4} + .56 + \frac{1.5r}{Z^2}}\text{——VI.}$$

From these equations we can get the running light current.

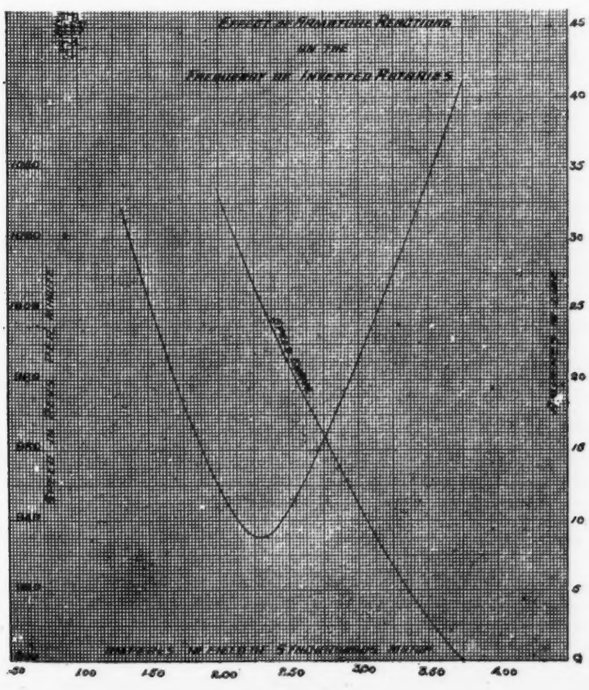

FIGURE 9.

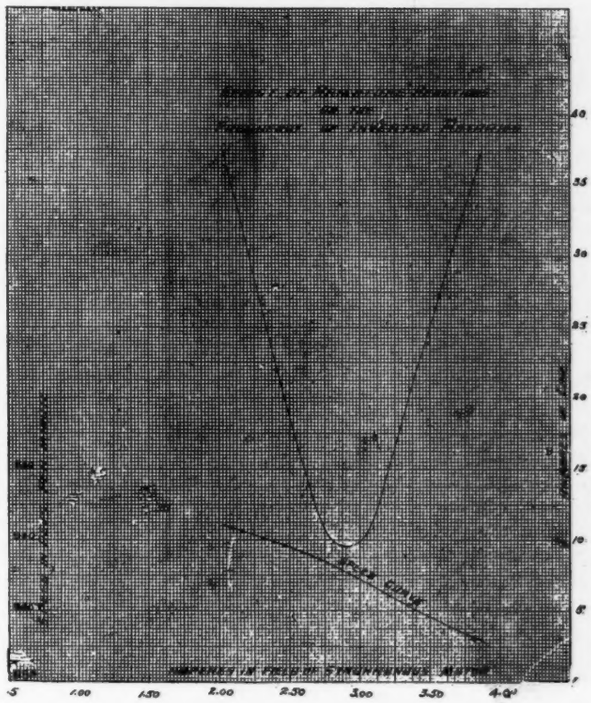

FIGURE 10.

The following would be the currents running light where converter would run non-inductively at full load Z = .1 — .4j:

r	x	Z^2	i_1 % of full load current.
.10	.40	.17	.42
.20	.40	.20	.64
.30	.40	.25	.84

Converter to run non-inductively at ¾ load.

r	x	Z^2	i_1 % of full load current.
.10	.40	.17	.31
.20	.40	.20	.45
.30	.40	.25	.63

From these results we see the effect of the energy loss on running light current. It is also evident the more the energy loss the higher should the generator voltage be relative to the converter voltage. It also shows that it is better to run the converters non-inductively at ¾ load, as before stated.

INVERTED ROTARIES.

In some cases rotary converters are used to change continuous currents into alternating currents, or as inverted rotaries. Trouble arises immediately when the power factor of the line changes to any extent as it is accompanied by a change in the frequency of the machines. The reason of this is very readily seen. A continuous-current shunt motor will speed up and down according as its field is weakened or strengthened, and for the same variation in field strength at light loads its speed will change more than at full load. As an inverted rotary is nothing more or less than a direct-current motor running light, a very small change of field strength is accompanied by a large variation in speed. The effect of lagging and leading currents on an inverted rotary is to speed it up and down. One way of getting over this difficulty is to strengthen the field of the inverted rotary, as lagging currents come on or weaken it for leading currents. An ingenious and automatic way of meeting this difficulty was devised and put into practice by B. G. Lamme, which is as follows: The inverted rotary is made to drive its own exciter, which may be placed on the end of the shaft or belt driven from it. (No. 8.)

The exciter should be worked low on its magnetization curve so that a small variation of speed is accompanied by a large variation of voltage. Supposing that there was a lagging current on the lines the speed would rise, but the speed rising would

strengthen the field, and if the one tendency were made to counteract the other a constant speed would be obtained. The following are the results of experiments carried out to show these effects. The exciter not being a specially designed one did not keep the speed absolutely constant, but its effect is clearly seen.

In case I and II (figures 9 and 10, respectively) the voltage impressed on the armature of the inverted rotary was kept constant throughout, and in case I the field current was also kept constant; thus any variation in speed would be due to armature reactions.

To get a large variation of power factor, the field current of the rotary converter was varied, and speeds as well as circulating currents were taken and plotted with field currents of the rotary converter as abscissæ.

The effect of the exciter in case II is very readily seen, as for the same variation of field current in case No. I the speed changed from 900 to 1036 revolutions per minute, and in case II the change was from 892 to 926. If the inverted rotary were equipped with a compensating exciter similar to the one patented by E. W. Rice of the General Electric Company, then theoretically the frequency would be constant.

Another way which might be used is to automatically vary the field by having a Siemens epicyclic train, one wheel connected to the rotary, another to a constant speed motor, and the third connected to the field rheostat.

As regards their practical operation, inverted rotaries are now being used to advantage in transmitting continuous-current power (from large direct-current power stations) long distances.

POWER FROM WAVES AND TIDES.

With visions of exhausted coal supplies, even though the end be far off, come thoughts of power from sources other than coal, from wind and water, and from the restless ocean waves and tides. Of water-power there are a goodly number of important installations, principally in the United States, where electric power distribution from them over comparatively long distances has reached a high state of development. In Great Britain, on the other hand, power from waterfalls is a scarce commodity and not much is to be hoped for in this direction, so that there is something of interest in a recent forecast, of the country, with every hill or other point of vantage studded with hugh windmills for generating electricity, to be subsequently distributed to manufacturing centres. Many years, however, would have to elapse before coal would become sufficiently dear to make such a scheme worth considering in a practical way. Wave motors and tide-power schemes have been almost endless in number. The former have, in a few instances, been used for light pumping work at seaside places, but such pumping outfits have been very far from demonstrating that the wave motor could ever be seriously considered as a prime mover where large powers were demanded; in fact, the wave motor is little better than a toy.

As to power from the tides, there is little to be said, except that much money has been wasted in vain endeavors to turn it to practical account. The tide-power scheme probably always will be alluring and also disappointing. The disappointment comes from the fact that very few people seem to take the trouble to figure out how much water and how considerable a fall are required to give any useful amount of power. A horse-power for a day of ten hours, for example, is calculated* to require something like 120 tons of water falling from a height of 100 feet, so that a 500 H. P. factory, say, would need 60,000 tons of water at a 100-foot head. On the basis of 36 cubic feet of water to the ton, there would thus be over 2,000,000 cubic feet of water, and this would make a fair-sized pond, say, about 1000 feet long, 200 feet wide, and 10 feet deep.

There is in these few figures something that may help to open the eyes of the tide-power plan inventor and of those who are in the habit of putting money into such things.

*Cassier's Magazine, Vol. XVIII, September, 1900.

Gas

INDUSTRIAL GAS. XV.

BY FRANK H. BATES.

[CARPENTER'S CONSTANT-PRESSURE CALORIMETER—CONTINUED.]

A CHART may be constructed by taking the number of British thermal units in the sample as abscissæ and the number of corrected scale-readings as ordinates, and drawing an oblique line from the point of crossing to zero.

Example illustrative of operation:

Weight of crucible and coke in grams - - - - - 3.002
" " " ash " - - - - - 1.064
" burned pure carbon " - - - - - 1.935

1.935 grams reduced to pound = .00426 pounds.

$1.935 \times .00205 = .00426$ pounds.

$14540 \times .00426 = 61.86$

1.935 grams reduced to pounds = $1.935 \times .00205$ (equivalent of 1 gram in pounds) = .00426 pounds.

14540 (B. T. U. per pound of pure carbon) $\times$ .00426 = 61.94 B T. U. in sample.

First scale reading, 3.35 inches; time 11 o'clock, 15 min.
Second " " 16.85 " " 11 " 40 "
Third " " 16. " " 12 " 10 "
Actual reading - - - 16.85 — 3.35 = 13.50 inches.
Cooling correction - - 16.00 — 16.85 = .85 "
Corrected scale reading - - - - - - - 14.35 "

Operation. 1. Select an accurate sample by a system of quartering, which shall commence by a very great amount, if possible, and finally terminate with a very small fraction of a pound.

2. Reduce to powder by grinding, in a mortar or mill, sufficient coal for several samples. A coffee-mill answers excellently for this purpose.

3. Introduce the sample into a small asbestos cup. Drive out moisture by warming it over a Bunsen burner or alcohol lamp. Weigh accurately on a fine chemical balance-scale.

4. Introduce the sample into the calorimeter; *(a)* start the oxygen gas flowing; *(b)* fire the charge, which should be done by pressing on a key; *(c)* at instant coal is lighted throw off the current and note the reading of the scale and time. During combustion keep the discharge orifice open, occasionally trying it with a small wire.

5. Watch the combustion, which will usually require about ten minutes for each gram of coal, and when completed note the scale reading and the time. The difference between the first and second reading is the actual scale reading.

6. To correct for radiation, note the amount the water in the column has fallen for the same time as required for combustion; add this to the actual reading to get the corrected scale reading.

7. Divide the value as shown on the diagram by the weight in pounds of the sample burned. The result will be the value in B. T. U. of one pound of coal.

8. Remove the dish in which the combustion took place; weigh it carefully with and without contents. If

the combustion has been perfect, the difference of these weights gives the ash. Wipe the combustion chamber dry for another determination.

9. To prepare for another determination, remove the calorimeter from the outside case and immerse in cold water, care being taken to prevent any water entering oxygen tubes or combustion chamber.

This method is preferable to emptying the calorimeter and adding fresh water each time, since the air, which is always present in water, will affect the result and is a difficult element to remove. The operation of cooling takes but a few minutes and is easily performed.

Derivation of results. Carpenter employs the calibration curve or chart for giving final values. This is drawn as directed under calibration, and its application is shown in the example cited below.

The methods adopted with the oxygen calorimeter, inclusive of the use of a constant, are also applicable to the derivation of results with this instrument.

The form for tabulating results is arranged for both the calibration curve and previous methods, and provides for a possible correction for residue (to be determined as directed for with the oxygen calorimeter).

Example illustrative of operation:

DETERMINATION OF THE CALORIFIC POWER OF ..... COAL

Date	*Locality*	*Notes:* Carpenter's Calorimeter employed.
No. 1	.....	

WEIGHTS.

Weight of crucible (asbestos)	1.269	grams
" " and sample (coal)	3.017	"
" " and contents after ignition in calorimeter	1.567	"
" " and contents after ignition in blast-lamp	1.567	"
" sample (coal)	1.747	"
" residue and non-combustibles	.297	"
" residue	.000	"
" non-combustibles	.297	"
" combustibles	1 450	"
" sample (1.747 grams × .002205)	.003852	lbs.

SCALE READINGS.

First scale reading	3.90 inches.	Time, 2h.	55′ 0″
Second " "	14.70 "	" 3h.	20′ 0″
Third " "	14.30 "	" 3h.	45′ 0″
Actual " "	14.70 — 3.90 =	10.80 inches.	
Cooling correction	14.70 — 14.30 =	.40 "	
Corrected reading		11.20 "	

One inch of scale by calibration test equals ..... B. T. U. per pound of fuel burned. Hence

..... inches (corrected scale reading) multiplied by .....inches (scale constant) = ...B. T. U. per.....pounds; or,

$\frac{\text{..... B. T. U.}}{\text{.....pounds}}$ = ... B. T. U. per pound;

and.....grams (weight of residue) × .002205 = ...pounds; .....pounds × 14544 (B. T. U. per pound of carbon = ... B. T. U. correction for the residue of the sample; then

$\frac{\text{.....}}{\text{.....}}$ = B. T. U. correction for residue per pound; and

..... B. T. U + ... B. T. U. = ... B. T. U. per pound = total calorific power.

Derivation of final value from calibration curve.

On the diagram* 11.2 corresponds to 46.25 B. T. U. in sample. As 46.25 B. T. U. are for .00385 pounds, one pound will be:

46.25 ÷ .00385 = 12000 heat units.

REMARKS.

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Special hints. When oxygen gas is not procurable under pressure in cylinders, it may be generated by heating a mixture of three parts of chlorate of potash and one part manganese dioxide in an oxygen flask or closed iron retort, the generated gas being passed through a wash bottle and collected in a gasometer, made by filling two cylindrical tanks (each open at one end) with water and inverting one into the other so as not to include any air. Weighting the upper tank will give the required pressure (after the oxygen has been collected).

For heating the platinum wire for ignition use 16 Mesco dry batteries, connected in four series.

In using the calorimeter see that all air is removed from the water and that the oxygen supply be maintained at constant pressure. When employing the calibration curve, use the pressure under which the instrument was calibrated or make a new calibration if other pressure is used.

Do not attempt to use the calorimeter in a room whose temperature is above 80 degrees Fahr., as the calorimeter should always be warmer than the air of the room.

(Continuation in December number.)

GAS ENGINE ECONOMY.†

BY E. W. ROBERTS.

ALTHOUGH the gas engine has made rapid progress during the last decade, and the improvements that have been developed have increased both the efficiency of the engine and its steadiness of running, there yet remains a field for improvement that includes within its bounds great possibilities. The gas engine, as it stands to-day, has many faults. These are, indeed, counterbalanced by its many virtues, and for that reason the faults are overlooked in extolling its merits. There is nothing better than competition to spur inventions and improvements, and the rapidity with which the power-using public is taking up the gas engine augurs well for its future.

To begin with, the gas engine as built at present has a terminal pressure within the cylinder averaging about thirty-five pounds to the square inch. If products of combustion are allowed to leave the exhaust pipe at this pressure, the resultant noise is so great as to constitute an objectionable feature. Therefore the exhaust is led through a series of tortuous passages in order to quiet it, with the result that the back pressure in the engine is increased, with a consequent loss of power in the engine. Although the compound engine and the variable-stroke engine have been tried and abandoned, the writer believes that there is ample opportunity for improvement in this respect. An increase in the expansion would give at least 10 per cent. increase in power for the same fuel consumption, when employing the

*In case the calibration curve is employed.

†*The Gas Engine.*

compression pressures now in general use. There would also be absence of noise, as the terminal pressure could, in all likelihood, be brought to within four or five pounds of that of the atmosphere.

It is not realized by every gas engine manufacturer* that the advantages of the multiple-cylinder engine are numerous. In the first place, an increase in the number of cylinders is conducive to steady running, as is generally admitted. The decrease in the necessary weight of the flywheel is not only of advantage in the saving of iron, but it also reduces the friction of the engine to a marked degree, and, consequently, increases the mechanical efficiency of the engine. In a multiple-cylinder engine there are opportunities for balancing which are lost sight of by the majority of designers, and much has been done in this line in a hit-and-miss sort of way. There is much literature on the subject of balancing, and very few writers agree as to proper methods. In fact, the gas engine builder quite frequently has derived an empirical formula of his own which gives results that are, in his estimation, good enough, but by no means perfect.

There is also a chance for improvement in the handling of the water that passes through the water-jacket. In factory tests it has been found that the best results were obtainable when the temperature of the water of the water-jacket was 150° Fahr., this temperature varying in different engines. But the writer has yet to see a single gas-engine instruction sheet in which this fact is mentioned. In fact, no attention whatever is paid to the jacket water after the engine leaves the factory. Now, why should this be so? Is it because the gas engine is the motive power for the ignorant or the indolent? The writer admits that this matter does not assume great proportions in the engines of small dimensions; but the question arises: would it not pay to employ a temperature regulator on the engine that would control the temperature of the engine cylinder by means of the water supply? It would be absolutely useless to leave this regulation to the engineer unless the engine were operating under a comparatively constant load, for with a diminution of the load the water supply should be decreased, and *vice versa*.

The question of high compression is a matter that is a puzzle to the average gas engine builder. The writer has quite frequently been asked for his opinion on this question, and usually with an inflection that showed plainly the questioner's aversion to increase of compression pressures. And why this aversion? The answer is not hard to give. The gas-engine builder who already has an established line of patterns and has tools, templets, etc., which are adapted to the particular designs which he has in hand, finds that to increase the compression means a necessary strengthening of his engine in almost every part. It is notorious that the average gas engine is seldom built too strong for its work, and an increase in compression is, perhaps, a harbinger of frequent breakdowns. There is, however, no reason that when a new design is contemplated it should not be so proportioned that it can withstand the increased pressure.

With increased compression comes the danger of premature ignitions, commonly known as "backfiring," and there is a limit to compression for each fuel employed which depends almost entirely upon the ignition temperature of that fuel. For this reason compression can not be carried to so high a temperature when gasoline is the fuel employed as when the fuel is natural or artificial gas. Gases rich in hydrogen—as those made by the water gas process—are also an obstacle to high compression. The compression of a charge of pure air and the subsequent introduction of the fuel at the end of the compression is a method that overcomes this difficulty, but is covered with patents, and can not be employed by the gas engine manufacturer without the payment of royalties. The subject is one that has been given considerable attention by a prominent firm of gas-engine builders, and the results obtained indicate that the subject is one worthy of consideration, and that an increase in compression carries with it an increased economy of fuel consumption.

A matter which appears to have but little attention from the gas-engine designer is the proportions of the inlet and exhaust passages. These are too frequently made much smaller than they should be, and often without apparent reason. In a series of engines recently examined by the writer, no regularity of proportion was apparent, as the ratios of the passages to the volumes of the cylinder and the piston speed were the same in only a few instances. The designer did not seem to realize that throttling the air as it entered the engine would reduce the volume of the charge, nor that an obstructed exhaust would increase the back pressure on the piston. In several cases the valve openings were ample, but the port leading from the valve box to the cylinder was contracted, although there was more than enough room to have it made larger. There is another class of designers who give both valve openings the same area, while the usual excuse for this is that if the exhaust valve is big enough the other is also; yet it seems to the writer that it is a confession of inability to decide what is the better size in either case. To make the valves big enough is all well and good, but there is a practical limit beyond which it is always foolish to go, as to make the valves or passages larger than necessary requires an unnecessary expenditure in the manufacture. Fortunately or unfortunately, the upper limit is not very often passed, and it is found in practice that the engine could be much improved by increasing the inlet and the outlet passages.

There is still another question that bears very strongly on the economy of the gas engine, and that is the question of load. All gas engines give their best performance at nearly full load. There are but few power requirements in which the engine would run at its full load for the major portion of the time it is in use. The engine is guaranteed to produce a horsepower on so much fuel per hour, and it does very nicely when the load is that at which the engine is rated; but let the load fall off 50 per cent. or more, and note the enormous falling off in economy. But how avoid it? The problem is nicely met by dividing the load between several engines. Thus, if the maximum load is 50 horsepower, install a 20 and a 30 horsepower engine. When the load is one-half of the total and not more than three-fifths, the larger engine may be employed. When the load drops below two-fifths of the whole, the smaller engine may be employed, and when the power requirement is too great for the larger engine both may be used together. Of course, this plan is not practical when the load is changing between wide limits in a short interval of time, but there are many cases where it may be applied. A plan which is better adapted to the latter case, and where the requirements for speed regulation are such as to permit its use, is to employ a multiple-cylinder engine and govern it by cutting out one cylinder at a time, instead of having the impulses stopped on all the cylinders at the same time. This plan is already in use, and it is understood to be a success.

In all gas engines, and in gasoline and oil engines especially, the combustion of the fuel is a point that may be well looked after. Imperfect mixtures, especially those which are too rich in fuel, often result in the discharge of unburned material into the exhaust passages. The best way to determine the state of the mixture in the gas engine cylinder while the engine is running is to place a small pet cock on the cylinder in such a position that it opens directly into the compression space. When this pet cock is open and a part of the mixture is allowed to escape at the time of the explosion, the color flame gives a good indication of the proportion of gas in the charge. If this proportion is about right, the flame will be a deep blue, similar to that at the base of a Bunsen flame, while should the proportion of gas be too great the point and the edges of the flame will be tinged with orange. And this, by the way, is a very simple method for determining the proper opening of the gas valve.

While the maximum economy of the engine is obtained when the engine is giving nearly all the power that can be obtained from it, the point of least fuel consumption lies somewhere just below the point of greatest power. The mixture which will develop the highest mean effective pressure does not of necessity waste the least gas. It is, therefore, well to determine the point of greatest economy, and to so proportion the engine that the load it is required to carry is as nearly as possible at this point.

*Engines of this class are typified in the 300-horsepower gas engine now being built by the Union Gas Engine Company, San Francisco, for the San Francisco Gas and Electric Company. For description see THE JOURNAL for September, 1900, page 68, *et seq.*—THE EDITOR.

Traction

THE NELSON, B. C., TRAMWAY PLANT.

BY J. P. WILSON.

IN Nelson, British Columbia, during the month of December, 1899, the first railroad in central British Columbia was opened for regular service. Nelson, a city of about 10,000 inhabitants, is one of the most progressive cities in British Columbia.

Within the last year the Nelson Electric Tramway Company obtained a charter from the city to operate an electric tramway. The tramway is at present about three miles long, but will probably soon be extended to one or two of the suburban mining camps. There are three cars, each equipped with four G. E. 1000 motors, controllers and brakes. The grades are very heavy, maximum 17 per cent., and the cars, especially on Sunday, are generally heavily loaded. After considering the question of motive power, the company finally concluded to give the West Kootenay Power and Light Company of Rossland the contract for supplying 500 horsepower, to be transmitted electrically from the generating station at Bonnington Falls on the Kootenay River, a distance of 12 miles from Nelson.*

The West Kootenay Power and Light Company's sub-station in Nelson closely resembles the one in Rossland, as does also the Nelson pole line, but the latter was not roofed as was the Rossland transmission pole line. The two lines are of No. 8 B. & S. hard-drawn wire, and supported throughout on porcelain triple petticoat insulators of Redlands type. The lines pass through the end of the sub-station, where the usual equipment of choke coils and lightning arresters is placed, to a high-tension switch-board consisting of two blue Vermont marble panels, each mounted with a double-throw, quick-break switch, and containing the usual facilities to afford safety and celerity in the handling of both the lines and banks of transformers. For instance, both lines can be fed into the same transformer, or, to make still better regulation, one bank of transformers can be fed from one line for the railway load, leaving the other line and bank of transformers for the lighting load. The latter are of the usual air-blast type. The primaries take either 9600 or 16,000 volts, according to whether connected in delta or in star, while the secondaries deliver 2200 volts.

The three-phase current at 2200 volts is led direct through the low-tension switchboard to a Canadian General Electric revolving field 350-kilowatt synchronous motor, the designation of which is "A. T. 18, 350, 400, 2200," and which is directly connected to a 325-kilowatt direct-current generator on the same base. The designation of the latter is "M. P. 6, 325, 400, 550." This generator furnishes direct current to the railway. The switchboard at present is a three-panel one. The railway generator panel is of the customary type, with a large Weston station voltmeter swung to the side, and is provided with a magnetic blowout circuit-breaker at the top of the panel.

The synchronous motor panel is similar to the machine panels at the main plant, being equipped with a Thomson alternating voltmeter and three ammeters, oil-break switch, "I. T. E." circuit-breaker and field rheostat.

The third panel is one on which is mounted a synchronizing device, exciter ammeter, field rheostat, and a special switch for the 30-horsepower starting motor, which is located on the base of the motor generator, set and connected by a gear and clutch to the main shaft. This starting device has proved very successful.

All track through the city is laid with 72-lb. T rails on cedar ties. The rail joints are bonded with 000 rail bonds, and cross-bonded at frequent intervals. All poles are of cedar, overhead construction being supported by G. E. apparatus. The trolley wire is No. 0, fed at frequent intervals from a No. 00 feeder.

The Nelson Electric Tramway Company (Limited) is an English company, and was promoted and organized through the energy of W. H. Drummond.

*A complete description of this plant was given in May and June, 1899, issues of THE JOURNAL.

Operation

JOINT D. C.-A. C. TRANSMISSION.*

BY FREDERICK BEDELL, PH. D.

NO ENGINEERING obstacles arise to detract from the desirability and practicability of systems for the joint transmission of direct and alternating currents from the point of view of copper saving. The requirement is a system of line distributing whereby independent alternating and direct current generators may supply current to independent alternating and direct current apparatus, the alternating and direct currents being independent in their generation and utilization and combined in their transmission.

That the two unlike currents may be transmitted over the same wire and not interfere with each other is thus explained: Suppose to a direct current of 10 amperes is added an additional ampere of like (direct) current. The whole current becomes 11 amperes, which flows with uniform density in the conductor, so that the original current of 10 amperes has only ten-elevenths of the conductor for its use. An additional current of like kind, therefore, interferes with the original current. But if, however, to an original direct current of 10 amperes there be added an ampere of alternating current, then half the time this ampere of alternating current is of the same polarity as the direct current and increases the current density in the conductor; but half the time the alternating current is opposite in polarity to the direct current, and during this time makes the total flow of current less, and the current density less, than for the direct current alone. In other words, the additional ampere of direct current interferes all the time with the original direct current, whereas the additional ampere of alternating current is a detriment half the time and an assistance half the time, these two effects tending to cancel.

Each current acts as though it had the whole conductor to itself, and hence the line loss depends upon the sum of the squares of the two currents, and not on the square of their sum. In a given conductor of resistance equal to R, and two unlike currents C and c, the losses are:

$$RC^2 + Rc^2$$

If they were two like currents, the losses would be:

$$RC^2 + 2RCc + Rc^2$$

The saving in line drop, or in copper, may be as much as 50 per cent.

The conclusion is that since direct current can be transmitted on the whole more economically jointly with alternating current than separately, it follows that the radius of economic transmission of direct currents can be thus extended.

*Abstract of a paper presented before the New York meeting of the American Association for the Advancement of Science, June 26-30, 1900.

Literature.

PHOTOMETRICAL MEASUREMENTS, by Wilbur M. Stein, Ph. D. Size, 5×7¼ inches; 12mo., cloth; 270 pages; 67 cuts and illustrations. Published by the Macmillan Company, 66 Fifth ave., New York. Price, $1.50.

The general practice of photometry, with especial reference to the photometry of arc and incandescent electric lamps, is set forth by Prof. Stein in this little book in such a brilliant manner that all will recognize in it a perfect gem of technical literature. In truth, its perusal will doubtless convincingly reveal to the general electrical reader for the first time the exhaustive thoroughness with which the phenomena attending the measurement of illumination have been studied, and he will, after having digested the laws which Prof. Stein has so effectually presented, appreciate the fact that a reasonably thorough comprehension of the science of photometry is far more essential to the administration of any lighting industry to the highest possible degree of success than is generally supposed. This is, above all others, the age of special-

ization, and Prof. Stein has in the present work presented the electric lighting industry with the means for attaining a vast improvement in the methods now commonly in vogue. By this is meant that greater familiarity with the laws of light cannot but redound to the ultimate advantage of any concern that is engaged in the manufacture and sale of any commodity used in the production of light.

The contents of the book are embodied in seven chapters and an appendix wherein are discussed (*a*) the absorption of light by globes and the action of reflection, (*b*) recent investigation of Lambert's law for the reflection of light, and (*c*) a table of ratios for a 100-part photometer bar. The body of the work considers physical and physiological principles of photometry, with definitions of photometrical quantities and units, and a study of photometers and standards of light in primary and secondary values, together with the photometry of incandescent and arc lamps, respectively. All are handled in the masterly style of an author who possesses an exhaustive understanding of the subject upon which he writes, who appreciates the need of the industry to which he is catering, and who writes in language so clear and so concise, and yet so thorough, that all who read may comprehend. Prof. Stein's book is, in brief, alike iuvaluable to the manufacturer, the seller, the buyer and the user of electric lamps of either the arc or the incandescent variety.

STANDARD POLYPHASE APPARATUS AND SYSTEMS, by Maurice A. Oudin, M. S., member Am. Inst. Elec. Engrs.; 249 octavo pages; 159 figures, illustrations and diagrams, with several tables and charts for the calculation of transmission lines. Published in 1899 by D. Van Nostrand Company, 23 Murray street, New York. Price, $3.00.

The appearance of Oudin's "Polyphase Apparatus" marks the advent of the first book that deals with the purely technical side of the apparatus and methods of polyphase generation, transmission and distribution in a manner bound to be eminently satisfactory to the busy transmission engineer and hard-working operative of polyphase machinery who, above all others, seeks cold facts simply and convincingly stated. There have been other excellent books published pertaining to polyphase machinery and methods, notably Bell's "Electric Power Transmission" and S. P. Thompson's "Polyphase Electric Currents"; but while Bell's book discusses the general aspects, that is, both the technical and commercial features, of electrical transmission in a way that is exemplary to the practical man, and while Thompson's work, though invaluable to all, refers more especially to British and Continental methods than to American, in Oudin's "Polyphase Apparatus" is found a treatise dealing with the subject exclusively from the standpoint of American electro-technical practice. Theory seems to have no place in the book, not that the value of theory is to be discounted in any sense, but because the work is essentially of a practical nature, written by a practical man for the benefit of other practical men.

Prior to the appearance of Bell's book the only literature available concerning polyphase practice was to be found in the files of electrical periodicals or in the engineering circulars of the principal electric manufacturing companies. And, by the way, some of the most valuable information to be found in all electro-technical practice appears in these confidential trade circulars, such as the "Technical Letters of the Engineering Department of the General Electric Company," for instance. Now Oudin has given to the public much of that which heretofore has been buried in files of the electrical papers or under pledges of confidence, and it really seems as though he had, in writing this book, received the distinct authorization of at least one of the great electrical manufacturing companies to publish all that was known concerning the general characteristics and principles of construction and operation of each and every piece of polyphase apparatus of American manufacture, and Oudin's book and Bell's do not conflict; each is on a distinctive plane, yet each may well be regarded as supplemental to the other. Above all, each must be in the library of every one who desires to be well informed in matters pertaining to polyphase practice.

TRADE LITERATURE.*

General Electric Bulletins. No. 4219, "Induction Potential Regulators," descriptive of the general and theoretical principles, methods of operating, mechanical and electrical designs, methods of cooling, sizes, etc., of the latest IRT type of G. E. potential regulator, which, with its limiting switch connections, was diagrammatically described in the JOURNAL for November last (Vol. VIII, page 119). Illustrations of the stationary and movable cores and of other features are given. No. 4220, "Automatic Circuit Breakers, form CD, for 125 and 250 volt D-C. Circuits." No. 4221, "The G-E-54 Railway Motor." No. 4223, "The Thomson Recording Wattmeter for Street Railway Service." Meters on lighting circuits increase the lighting capacity of the station by nearly 30 per cent. Many railway managers agree that the average waste due to carelessness of the motorman amounts to 20 per cent. or more of all the energy consumed, and from recent tests as much as 30 per cent. difference has been found among motormen running the same car under almost exactly similar conditions. The instrument illustrated and described in this bulletin enabled a street railway manager to keep tab on the individual motorman. No. 4224, "Air-Blast Transformers." The latest forms of air-blast transformers are described, and methods of cooling, construction, magnetic core, terminals, tests and standard designs are discussed. No. 4225, "Direct-Driven Continuous Current Generators for Lighting and Power." A description, with mechanical and dimensional data, of 125 and 250 volt D-C. generators. No. 4226, "Continuous-Current Railway Switchboards. No. 4227, "The C-E. Motor," being of slow and moderate speed types in sizes from 2 to 15 horsepower. *General Electric Company.*

Westinghouse Bulletins. No. 1018, "Alternating-Current Switchboards," for polyphase circuits, type 6, 100 to 600 volts; No. 1019, *ditto*, type 6, 1100 to 2200 volts; No. 1020, *ditto*, type 8, 100 to 600 volts; No. 1021, *ditto*, type 8, 1100 to 2200 volts. The preceding switchboard bulletins treat of their respective subjects in a uniform way. General descriptions are given under the headings of frame, wiring and connections, multiple running, control of exciters, indicating instruments, field ammeters, swinging voltmeters, switches, rheostats, fuses, synchronizer and ground detector, transformers and compensators, wattmeters, etc. Each type of panel is described in detail. No. 1022, "Standard Railway Switchboards," type 5, with schedules of apparatus used on its generator, rheostat, load, feeder and special feeder panels; No. 1023, "D-C. Lighting and Power Switchboards," type 5, for potentials not exceeding 750 volts, with detailed schedules as in bulletin No. 1022. *Westinghouse Electric and Manufacturing Co.*

"The Mechanical Equipment of the New South Station at Boston, Mass.," is an invaluable paper of 124 pages, which truly constitutes one of the most remarkable pieces of engineering literature of a descriptive nature yet written. The paper was presented at the New York meeting of the American Society of Mechanical Engineers by Walter C. Kerr of the well-known engineering firm of Westinghouse, Church, Kerr & Co. The subject-matter is treated under the following headings: "Power-House," "Interlocking Switch and Signal System," "The Electric Plant," "Heating and Ventilating," "Disposal of Drainage from Waterproofed Structure," "Roof Drainage," "Ice-Making, Refrigerating and Water-Cooling Plants," "Car Heating in Train Shed and Yards," "Air-Brake Charging," "Steam and Hot Water Supply to Head-House," "Fire Protection," "Elevator, Baggage and Express Lifts." The publication has just come off the press, and it presents a subject of unusual interest to officials of railways, directors of banks, trust companies and industrial corporations, and to engineers in general. The Westinghouse Companies' Publishing Department will be pleased to send a copy of the paper gratuitously to anyone interested. Address the above department at Pittsburg, Pa.

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